PhD Modules (2019-20)

MODULE A

Title: *Network and Business Analytics*
Teacher: Andrea Fronzetti Colladon
Contact*:* andrea.fronzetticolladon@unipg.it
Indicative period: January (13—24). Ideally, the course will consist of 4 lessons (5 hours each), spread over 2 weeks (interested students should contact the teacher as soon as possible in order to define the schedule of the lessons).

ABSTRACT. We live in a world where everything is connected: people, information, places, events, genes in the DNA. A clever way to make sense of these connection patterns is to study them as networks. **Social Network Analysis** (SNA) refers to widely used methods to study networks, which can be applied, for example, in social and behavioral sciences, in management and innovation management, economics, marketing, biology, psychology or engineering. The focus is on relationships among social entities; examples include communication or opinion formation among members of a group, economic transactions between corporations, or diffusion processes. Online, taking the Web as a mirror of the real world, SNA opens up unprecedented opportunities to read the collective mind, discovering emergent trends and behaviors. The possible applications are so many that they cannot be numbered.
Students will learn about the structure and evolution of networks, but other approaches will be not ruled out. The teaching will combine knowledge from a broad range of disciplines. The course covers Business Intelligence methods and focuses on data science and business analytics. The knowledge acquired from the study of SNA will be complemented with elements of **Text Mining** and **Machine Learning** (Gradient Boosted Trees).
The course is divided into three parts: the first theoretical; the second devoted to the analysis of case studies; the third practical, aimed at the application of what has been learned. Students will learn how to use **specific software** – such as, SBS BI, Condor, Pajek or Gephi, and the Python programming language.

The acquired knowledge could be used in multiple fields, to solve multidisciplinary research problems.

PROGRAM.

- Introduction to Social Network Analysis (SNA): data collection, centrality measures, structural holes, clustering, network topologies, community detection, key roles, elements of diffusion and resilience.
- The Semantic Brand Score.
- The 7 Honest Signals of collaboration and communication.
- Research and business case studies. Business analytics applied to big data: social network analysis, text mining and body sensing.
- Methods and tools of analysis (not necessarily limited to the following): brand intelligence reports; network measures; text mining; gradient boosted trees; Shapley values.
- Online data mining: Twitter, Event Registry, emails.
- Software tools: SBS BI and Python (Networkx and other libraries). Other software, only if needed: Condor, Pajek, Gephi, Stata and SPSS.
- Data Science Lab. The students will work together during the course to analyze a real dataset and apply what has been learned.

The course program could be adjusted depending on the interests and skills of students. For example, elements of statistics could be covered, if students are not confident with the concepts of standardization, correlation, ANOVA or T-test. There are no prerequisites; however, students are expected to come with their laptop, where the following software should be installed:

- (Required) Python Anaconda Distribution: https://www.anaconda.com/distribution/
  Which includes the Spyder IDE.
- (Optional) Docker: https://docs.docker.com/install/
- (Optional) Java: https://www.java.com/en/download
- (Optional) Gephi: https://gephi.org/
- (Optional) Pajek: http://mrvar.fdv.uni-lj.si/pajek/
- (Optional) SPSS: https://www.ibm.com/analytics/spss-statistics-software

MODULE B

Title: *Measurement systems for localization*
Teacher: Alessio De Angelis
Contact*:* alessio.deangelis@unipg.it
Indicative period: January 7—February 14 (interested students should contact the teacher as soon as possible in order to define the schedule of the lessons).

ABSTRACT. Information about the position of users, structures, and systems is crucial in many engineering applications. This course presents an overview of the main characteristics and requirements of location-aware applications in several operating scenarios, together with the fundamental electronic measurement techniques. Methods and algorithms for static position estimation and dynamic tracking are also described.

PROGRAM

1 – Electronic systems for short-range distance measurement and positioning:
Characteristics and requirements of location-aware applications. Performance of available solutions: radio-frequency systems (Ultra-wideband, wireless personal area network), ultrasound systems, magnetic-field-based systems, integration with satellite positioning and navigation systems.

2 – Position measurement techniques:
Time-of-flight measurement: Time of Arrival, Time Difference of Arrival, Round-Trip-Time.
Power measurement: Received Signal Strength.
Direction measurement: Angle of Arrival.
Processing techniques: trilateration, triangulation, fingerprinting, dead reckoning.

3 – Methods and algorithms for position estimation:
Tracking, sensor fusion, seamless indoor-outdoor positioning, cooperative localization.

Evaluation: 50% lecture attendance, 50% final project: the students will perform an experimental project by processing measurement data, provide a report, and discuss results.

Suggested reading:
- Z. Sahinoglu, S. Gezici, I. Guvenc, *Ultra-wideband Positioning Systems: Theoretical Limits, Ranging Algorithms, and Protocols*, Cambridge University Press, 2011.
- Study material provided by the instructor.

MODULE C

Title: *Numerical Simulation of Electronic Devices with TCAD (Technology Computer Aided Design) Tools*
Teachers: Daniele Passeri and Arianna Morozzi
Contacts*:* daniele.passeri@unipg.it, arianna.morozzi@pg.infn.it
Indicative period: March-June 2020 (interested students should contact the teachers as soon as possible in order to define the schedule of the lessons).

ABSTRACT. The course aims to provide students with the methods and tools to perform the numerical simulation of electronic devices using technological CAD tools. In particular, the simulation of the integrated circuit fabrication process and the simulation of their operation at the device level will be discussed. The Synopsys Sentaurus software, currently at the state-of-the-art for process and device simulation, will be used.

PROGRAM

- Electronic devices fundamentals.
- Numerical simulation: physical models and numerical methods.
- Process simulation.
- Device simulation.
- Lab exercise: device simulation of MOSFETs, CMOS Active Pixel Sensors.

MODULE D

Title: *Multiphse models for the dynamics of fluids*
Teachers: Michele Battistoni and Luigi Vergori
Contacts*:* michele.battistoni@unipg.it, luigi.vergori@unipg.it
Indicative period: April-May 2020 (interested students should contact the teachers as soon as possible in order to define the schedule of the lessons).

ABSTRACT. Multiphase flows are widely used in a plethora of practical applications, such as spray, atomization, coatings, cavitation, phase change problems, cooling, microfluidics, in industrial and medical Engineering. The course aims at the introduction of mathematical methods for studying some multiphase flows of both incompressible and compressible fluids. Some applications will be discussed and numerical algorithms for the solution of the governing equations will be presented.

PROGRAM

Basics of the kinematics of fluids: Lagrangean and Eulerian descriptions of motion. Equations of balance of mass, momenta and energy. Constitutive theory of fluids. Cauchy stress tensor. Derivation of the equations governing multiphase flows in fluids. Separate flows: Eulerian description. Disperse flows: single and two-fluid Eulerian descriptions, Eulerian-Lagrangean description. Case studies on both Eulerian and Lagrangean models.

MODULE E

Title: *Analysis of Engineering Accidents*
Teacher: Paolo Conti
Contact*:* paolo.conti@unipg.it
Indicative period: April-May 2020 (interested students should contact the teachers as soon as possible in order to define the schedule of the lessons).

ABSTRACT. During the course, several engineering accidents will be illustrated, highlighting the evolution that led to the accident, the causes that caused it, the consequences and the lessons that must be learned. Some accidents had great media coverage; in this case the aim is to treat them on a technical level (an aspect usually ignored by the media) in order to highlight the errors that led to the accident and the safeguards that could have avoided it. In particular, the Chernobyl accident, fatigue failures of Comet aircraft and shuttle accidents will be discussed. Other accidents, less known, will concern specific industrial fields: gas turbine plants, aeronautical accidents, pressure vessels, failures due to overloading and fatigue. Based on these accidents, normal techniques in failure analysis and prevention will be illustrated: Root Cause Failure Analysis, Failure Mode and Effect Analysis and Fault Tree Analysis.

PROGRAM

1) The concept of risk in engineering
2) The Chernobyl Disaster (RBMK power plant description, events leading to the accident, the accident, effects of radiation from Chernobyl). Lesson to be learned.
3) Challenger and Columbia accidents (the Space Shuttle and the safeguards that could have avoided it). Lesson to be learned.
4) Fatigue failures of Comet planes (the genesis of the Comet project, underestimation of early accidents, misunderstanding of the fatigue effects). Lesson to be learned.
5) Accidents in gas turbine power plants. Accidents due to material degradation. Accidents due to Foreign Objects Damage (FOD). Accidents due to fatigue failures. Root Cause Failure Analysis.
6) Accidents in pressure vessels and pressure pipes. (effects of crack propagation, embrittlement of materials, accidental burst).
7) Root Cause Failure Analysis.
8) Failure Mode and effect analysis.
9) Fault Tree Analysis.